ready means throughout the 24 hours of ascertaining the visibility conditions on any part of the coast by listening in for a desired radiobeacon at any time other than its scheduled period.

As the radiobeacon signals may usually be heard at distances of 200 to 300 miles, this should often furnish useful or valuable information both to vessels approaching from seaward and to those bound along the coast. The radiobeacon system is now sufficiently extended that the signals overlap along the entire coast, and the signals from the 37 radiobeacons on the Atlantic, Gulf, and Pacific coasts now spread out over a sea area of over a million square miles.

Navigators have been availing themselves of this source of weather information, and it has been particularly mentioned in reports recently received from Commodore Hartley, formerly of the *Leviathan*, and Captain Williamson, of the *Kentuckian*. In one case Ambrose radiobeacon was used when passing Nantucket Lightship to judge of conditions at the entrance to New York, and in the other Blunts Reef radiobeacon was used by a coastwise vessel to ascertain conditions ahead of it.

551.515 (781)

TORNADOES IN KANSAS

By S. D. FLORA

Tornadoes are more numerous in May and June than any other time of the year in the Middle West, according to records of the United States Weather Bureau. In Kansas 53 per cent of the 177 tornadoes that have struck the State since 1913 have occurred either in May or June. The only months entirely free from them in the State in that time are January and December.

In the 13 years ending with 1928 more tornadoes occurred in Kansas than in any other State, as shown by a summary of the Weather Bureau record obtained through its network of almost 5,000 stations. When relative areas of States is considered, however, it is found that both Iowa and Arkansas have experienced more tornadoes in that period than Kansas. Actual damage by these violent windstorms has been immensely greater in Missouri than in either Kansas, Iowa, or Arkansas. Illinois, Indiana, and Ohio have also had a bigger tornado loss than the Sunflower State, largely due to the same cause.

The year 1928 set a new high mark for tornado frequency in Kansas, with a total of 26 recorded against a 15-year average of slightly less than 12. Kansas tornado losses for the period totaled $9,547,150 and 102 persons were killed, according to official estimates. This may seem high in the aggregate, but it is less than two-fifths of the property loss of the St. Louis tornado on September 29, 1927, and the fatality list is not a sixth as great as that of the tri-State tornado that struck Murphysboro, Ill., March 18, 1925.

One reason why Kansas tornado losses have been small, comparatively speaking, is that tornadoes in that State seldom travel more than 25 miles before they break up. In the Mississippi Valley some of them travel 50 to 150 miles. In Kansas a great many tornadoes pass over prairie country, where buildings are few and far apart, and finally draw up into the clouds with no more damage than a few out buildings wrecked and telephone lines and wind mills blown down. Kansas people in one respect, at least, are more fortunate than their eastern cousins. In most sections of the State the funnel shaped cloud can be seen approaching for several miles and there is a chance for a run to shelter in basements or "cyclone cellars." The latter, which are merely outdoor caves, are common sights near farm houses in central and western Kansas, where they are used for storage of vegetables and dairy products. Many a Kansas farmer and his family have emerged unhurt from a handy "cyclone cellar" after a tornado has passed over and house and barn have been swept away by the wind.

Only three Kansas tornadoes have been in the million-dollar class. One that struck Great Bend November 10, 1915, killed 11 persons and destroyed property to the estimated extent of $1,000,000. Another struck in the oil fields of Butler County July 13, 1924, tore up Augusta, played havoc with oil rigs, and caused a total loss of $2,000,000 and one person killed. The Hutchinson tornado of May 7, 1927, left its trail in five Kansas counties, Comanche, Barker, Kingman, Reno, and McPherson, killed 10 persons, and destroyed property to the extent of $1,300,000.

Tornadoes are undoubtedly more numerous than most persons realize. St. Louis has had two violent ones, on May 27, 1896, and again on September 29, 1927. Omaha had two that caused great destruction; the Easter storm of March 23, 1913, and another April 6, 1919. St. Joseph has seen four tornadoes in the past 14 years: One April 2, 1913; one March 3, 1923; one June 24, 1924; and the last on May 24, 1927. The Kansas Cities have two tornadoes in their history. The first struck Kansas City, Mo., May 11, 1886, and the last reached the western suburbs of Kansas City, Kans., July 16, 1927. Topeka has seen two tornadoes in recent years, but both were in its suburbs and caused very little damage. A violent tornado on June 5, 1917, registration day, missed Topeka by only a few miles. Four destructive tornadoes formed within a radius of 80 miles of Sioux City, Iowa, on September 13, 1928, and one of them, headed almost directly for the city, ended only 5 miles from the suburbs.

Science has devised no way of predicting when or where a tornado will strike or exactly what path it will travel once it starts. Weather Bureau officials recognize certain conditions that are favorable—sultry, "sticky" afternoons following mornings that are oppressive, especially in May and June, with an area of low atmospheric pressure shown on the weather map to the northwest—but the Weather Bureau makes no predictions of tornadoes. Even when conditions are apparently most favorable tornadoes may not occur at all and when they do appear there is no certainty in regard to what locality or even what State they will strike. Also, no successful effort has ever been made to warn cities of the approach of a tornado when it is traveling in their general direction. Wire service is always disrupted by such a storm and radio would be worthless on account of disablement of a sending station in the storm path. The tornado that struck Hutchinson, Kansas, May 7, 1927, had been traveling in a sweeping curve that carried it in a general direction toward that city for five hours before it finally struck. It narrowly missed one county seat and several small towns on the way and was seen by hundreds of persons, yet Hutchinson had absolutely no warning of its approach.

Personal safety when a tornado is approaching is either a matter of luck or the exercise of swift judgment. Accounts of tornado disasters are filled with reports of escapes that seem little short of miraculous and of sudden deaths from falling timbers, bricks, and stones.

The old-time "cyclone cellar" or outdoor cave has probably been the means of saving more lives from tornadoes than anything else and is still one of the best places of refuge ever contrived. The southwest corner of the basement of a frame house is almost as safe, especially if a person crouches close against the wall. Tornadoes nearly always approach from the south or west and flying débris or perhaps the house itself will be carried away from the southwest corner. The basement of a brick or stone house is liable to be a death trap in a tornado as brick or masonry walls are liable to collapse and tumble down anywhere.

A person caught in the open when a tornado approaches has a choice of lying down flat in a depression or of flight. Tornadoes travel across the country at a rate of 30 to 60 miles per hour, usually, and escape for a person in an automobile is simple if there are highways open. A person on foot directly in the path of such a storm should run toward the northwest, which is at right angles to the storm path and toward the side where the winds are least violent.

For a person caught in the business section of a city when a tornado is approaching perhaps the best chance would be to stand close to an inside partition of a modern reinforced steel and concrete building. Architects believe such buildings will resist side winds of a tornado and possibly to a considerable extent the full force of such a storm, though this has not been established definitely. In any case outside walls are more likely to be blown out than inside partitions and the latter might serve to protect against débris that falls from upper stories.

ÅNGSTRÖM ON RECORDING SOLAR RADIATION: A STUDY OF THE RADIATION CLIMATE OF THE SURROUNDINGS OF STOCKHOLM

551.590.2 (485)

By HERBERT H. KIMBALL

[Meddelanden Från Statens Meteorologisk-Hydrografiska Anstalt. Band 4. No 3; 36 pp., 2 Pl. 23 text fig.

In his preface the author states that:

> It is desirable that the results as regards the total radiation income from the sun and sky be brought into relation, not only with the variation of the dark outgoing radiation, but also with the radiation within special limited parts of the spectrum. In fact it is planned to add later to the present study a detailed treatment of these last-named questions.

The following quotations are from the introduction:

> Practically all the energy conveyed to the earth and its atmosphere is furnished by the radiation from the sun; and the only way in which this energy is able to escape from the system is through radiation back to space from the surface of the earth and from the atmosphere. Together with the processes of atmospheric circulation, through which advection and convection of heat is sustained, this uninterrupted exchange of radiation determines the horizontal and vertical distribution of temperature within the atmosphere. In fact, these two groups of phenomena, the circulation and the radiation processes within the atmosphere, are involved in one another to such a degree that it seems scarcely appropriate to speak of the one as more fundamental than the other. So much seems certain, however, that we shall never arrive at a clear understanding of the weather and its causes, without a detailed knowledge of the way in which radiation produces atmospheric circulation, and the latter, in its turn, acts back upon the radiation exchange itself.
>
> The fundamental groundwork for such a knowledge must be obtained through observations and quantitative measurements.

The importance is stressed of measurements of the total radiation (direct + diffuse) in both clear and cloudy weather. Subtracting from this total the "effective temperature radiation of long wave length," often called "nocturnal radiation," there remains the "heat effective net radiation," which is available for "raising the temperature of soil, or water, or air, and for evaporation, melting, and other processes of transformation of water."

* * * * *

> The total radiation income from sun and sky determines what we may call the illumination climate of a place, and for many purposes a measure of the former quantity gives also a sufficiently accurate measure of the natural illumination.

* * * * *

> The light from sun and sky is a necessary condition for the assimilation of plants, but all the different wave-lengths have not the same effectivity. Engelman finds two bands especially effective, one in the red between 650$\mu\mu$ and 700$\mu\mu$, the other in the blue at about 480$\mu\mu$. * * * It seems probable, however, that the effectivity of different groups of wave lengths is variable from case to case, and that for different plants or in different periods of growths of the same plant the one or the other group of radiation may play the most important part.
>
> For the first orientation we may regard the total radiation income from the sun and sky as a satisfactory relative measure of the intensity of light that is active in the processes of assimilation in nature.

* * * * *

> More and more the important part played by light for the health and comfort of man is beginning to be realized. * * * In what way this light acts on the human organism is still very little known. One of the chief conditions for further development is a thorough knowledge of the quantity and quality of the stimulant under various conditions.

Chapter 1 discusses "Instruments and Principles of Measurement." Much of what is given has been published previously,[1] but improvements in both pyrheliometer and register are described and instrumental errors are discussed.

Chapter 2 gives the results of measurements. For the period April, 1926–August, 1927, hourly, daily, and monthly totals of radiation as measured on a horizontal surface are given, and also monthly means of the hourly totals. There is also given the maximum recorded intensity for each day, which the author states does not occur during perfectly clear days, but when the sun is shining between clouds which reflect the radiation they receive The highest recorded intensity is 1.725 gr.cal. per minute per square centimeter, in June, 1927.[2]

Annual and monthly totals are given for the period July, 1922–December, 1927. The average daily totals for cloudless days, and for days with the sky completely covered with clouds, have also been computed for each month. With a clear sky the highest average is 650 gr.cal. in June and the lowest 50 gr.cal. in December.

Let Q_O = the daily total radiation with a cloudless sky.
Q_S = the daily total radiation with the sky covered with clouds.
S = the ratio of the recorded hours of sunshine to the possible hours (time from sunrise to sunset).

Then Ångström finds that

$$Q_S = Q_O(0.235 + 0.765\ S)$$

[1] MONTHLY WEATHER REVIEW, 1919, 47: 795; 1921, 49: 135.

[2] The legend to Figure 21 states that the three curves give momentary maxima, mean noon, and minimum noon intensities for each month during clear days. This appears to be misleading in so far as the two last-named curves are concerned, since they seem to represent the average and the minimum values irrespective of cloudiness.